The Future of Engineering at NASA Langley

Operation NEXUS

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Agenda

- NASA Langley Organization
- Background
- Process Overview
- Investigation Topics and Targeted Areas
- In-depth Example: Design Reviews
- Summary
In Spring 2016, NASA Langley Director of Engineering Ed Healy stood up a group to address the “future of engineering” with broad topics such as:

- What will engineering look like at NASA LaRC in 5, 10, 20 years?
- How can we update and enhance our engineering methods to be ready for these future changes?
- What should be done right now to address efficiency and effectiveness in engineering design?

Participating on the team was voluntary and to be fit within the employee’s assigned duties and tasks.

Joe and Kevin were asked to lead the group and participants were allowed to self-select based on interest.

- Original group was rather large but once totality of the effort was explained including the time commitment, the numbers dwindled down to about 15-20 total participants.
- Final participant group was skewed to early career level but all experience levels had representation.
ED Vision

➢ To be the premiere NASA engineering organization for developing and delivering advanced technology, prototypes, and flight systems that make the Agency’s missions and projects possible

Group Charter

➢ The NEXUS activity was initiated by the Director of Engineering to investigate opportunities to prepare the Engineering Directorate as a technical organization for how engineering will be done in the future.
   • Not a typical focus group
   • 9-12 month effort, but expected to initiate an enduring activity
   • Some funding provided (FTE, small procurement, travel) so not entirely whitespace

➢ Success Criteria
   • At least three recommendations implemented by the Engineering Directorate and/or Center

➢ Central collaboration hub is using Microsoft SharePoint – part trial, part ease of access/use
Phase I

- **Team formulation & brainstorming**
  - Initial Kickoff (June 2016) – Collected the group for initial guidance and input

- **Scope definition and refinement**
  - Brainstorming Session (July 2016) – 6 hour activity to collect input on expectations, stakeholders, and scope of study for the group
  - Several meetings to review the data from the brainstorming session
  - Review topics with ED (twice) and branch management (October 2016)

Phase II

- **Investigation execution**
  - Research topics (several in-depth sessions held, last in mid-March 2017)
  - Visit peers and partner organizations to compare tools, practices, and performance seeking opportunities to learn and improve Langley ED project execution (on-going, two site visits so far)

- **Draft initial recommendations**
  - Vet preliminary recommendation with ED community and key stakeholders (on-going)
  - Develop implementation plans (on-going)

Phase III

- **Formulate and present recommendations**
- **Integrate one or more proposed recommendations in current, candidate projects**
  - Already in process with two new projects
Three perspectives guided investigation (defined via group discussion)

- Improving "Team" Communication, Collaboration, and Documentation
- Reignite Skills and Cross-training for the Modern Age
- Highly-Efficient and Effective Design, Development, Testing, and Deployment

Each of these are still very broad areas for investigation

- Worked to whittle these down to specific topics so work could be divided among team (next slide)

Initial template for investigations

- What are the issues to be addressed (and why do they matter)?
- How do our peers resolve this?
- What are the collaborative or inter-personal aspects?
- What are the technical aspects?
- What options are there to address the issues?
- How would these be implemented?
The team selected and refined nine (9) specific topics for investigation

Team members within NEXUS identified to lead each

Four topics identified as already being actively worked by other NASA LaRC investigation teams
  • NEXUS will coordinate with the existing team

Five topics identified as NEXUS-led investigations
  • Perceived as critical to the Engineering Directorate’s advancement
  • Will still involve collaboration with other organizations across Langley and potentially at other Centers and organizations
1. Improved, real-time “team” communication/collaboration
   • Collaborate with NASA LaRC Office of the Chief Information Officer (OCIO)/Advanced IT initiative

2. Advance the use of MBE/MBSE approaches
   • Collaborate with NASA LaRC Model-Based Systems Engineering (MBSE) team

3. Use of Collaborative Engineering Resources throughout the project lifecycle
   • Collaborate with NASA LaRC Engineering Design Studio (EDS) team and OCIO

4. Infuse rapid prototyping and advanced manufacturing techniques into all phases of design and production
   • Collaborate with MakerSpace team
NEXUS-Led Investigations

1. **More Efficient Design Reviews**
   - Collaborate with Flight Projects and Small Project Initiative

2. **Revolutionary Project Documentation and Configuration Management**
   - Collaborate with Flight Projects and OCIO

3. **Developing and Training Systems Engineers**

4. **Incorporating non-traditional engineering method disciplines**
   - Collaborate with OCIO/Advanced IT and Mission Assurance

5. **Capture and leverage historical data (design, test, metrics) and knowledge**
   - Collaborate with OCIO/Big Data/Data Analytics
Several notes during workshops revolved around whether current NASA design review (SRR, PDR, CDR) process was useful/effective

- Stemmed from multiple dissatisfying results where reviews felt like “wasted time” and didn’t uncover issues that they should have
- Amount of effort required to execute a successful review dwarfed the perceived benefits of the review/review process

With these ideas in mind, the sub-team looking at this topic split the investigation into two tasks:

1. How can the review structure be modified?
2. How can more information be captured from the meeting/review?
Current structure involves routine steps: kickoff meeting, document drop, document review/comment period, and “day of the review” presentations

- The official “review date” comes at the end and culminates in a review of slides prepared by the project walking through various summaries from the material contained within the project documentation

Proposed structure would flip the routine around:

1. Kickoff meeting would be an in-depth explanation of the documentation to be dropped – initial questions with review panel/board
2. Document review/comment period opens – team monitors questions and addresses them as the period elapses
3. Review period wraps-up with summary of comments and team responses, with final unresolved issues discussed – any that cannot be resolved real-time become forward actions

A process similar to this has recently been employed by the Orion Ascent Abort 2 project
Based on multiple interactions with the Lockheed Martin Center for Innovation (Suffolk, VA) and leveraging Operations Research work during war gamming, the team is investigating the use of data gathering software and pre- and post-review surveys:

- Would allow both review panel and project team at-large to fill out surveys prior to the meeting/review, including demographic information.
- Users are uniquely identified, but kept (mostly) anonymous.
- During meeting, massive interactive discussion occurs in real-time – similar to group chat – which allows team to interact, answer questions.
- All data is captured and saved.

Captured data is processed after the review and cross-referenced with demographic information to provide project manager and review team with insight into sentiment, areas of concern, etc.

- NEXUS is exploring use of natural language processing (e.g., IBM Watson Content Analysis) to aid this approach.
NASA Langley Research Center is committed to understanding what the next 5, 10, 20 years of engineering will look like for us.

The Engineering Directorate’s NEXUS effort is a start to that process which has uncovered some areas to investigate and pursue.

The NEXUS team’s individual areas of investigation are starting to show promise including a potentially new way to approach design reviews (and possibly other meetings).

Next steps are to pursue partnerships and new ways to continue the work, but in a constrained environment.

Please provide feedback when you have a chance – we are always looking for collaboration/interaction with any organizations that have been through this kind of initiative before.
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**Schedule**

- **Phase I**: Kickoff (Jun), Brainstorming Session (Jul), Define Investigation Topics (Aug), Benchmark Visits (Sep-Oct), Workshops (Sep-Oct), Integrate Observations (Oct-Dec), Initial Recommendations (Dec-Jan), Pilot Activities (Jan-Jun), Updated Recommendations (Jun-Jul)
- **Phase II**: In development
- **Phase III**: Transition NEXUS Team (Jun-Jul)
Benchmarking Efforts

- Identified ~25 candidate sites for benchmarking
- Candidates include aerospace, aeronautics, automotive, DoD, commercial, and academic
- The list is being refined relative to:
  - The specific topics identified for investigation (perceived value in the visit)
  - Practical limitations (cost, availability, and proximity) – will try to group into geographic regions to hit multiple sites with one trip
- Proposed visits:
  - Southern CA: JPL, SpaceX, Scaled Composites
  - Northern CA: Autodesk Pier 9, NASA ARC, Naval Postgraduate School, Apple, others (IDEO?)
  - Seattle, WA: Blue Origin, Boeing, Electroimpact (fiber-placement machines)
  - Denver, CO: Sierra Nevada (completed), LMSS/ Digital Tapestry, BATC, ADAPT at Colorado School of Mines
  - DC Area: MITRE
Look at ways for more real-time, integrated comm solutions

Better way to do design reviews - with two options:
- Constrained to current project/task framework (SRR, PDR, CDR, etc.)
- Unconstrained (task-based? Something else?)

Better task/project documentation - convert to fully electronic EVERYTHING
- Requirement and verifications
- Plans and other documents
- Procedures and build documentation (travelers, drawings, etc.)
- Test Reports
- Technical Memos
- Review materials
Focused on development of capabilities in our staff (i.e., how to develop systems engineering skills and capabilities).

- What is the proper mix of deep-knowledge SMEs and broad systems thinkers?
- How are these people trained?
- What skills are missing? Data analytics? Quantitative analysis? Others?

Original submission included two top-level perspectives:

- How we develop systems engineers
- Tools, processes, and methods – covered in the Design Environment topic
How to encourage fast maturation from idea to requirements to design to production/execution

- Investigate use of model-centric methods for enhanced design environment
- Investigate better incorporation of EDS into detailed design and production phase
- How do you properly validate outputs from the design effort, especially if it is model-based/virtual?

How can early/often integration of rapid prototyping being used effectively to not only make the design product more intuitive but also decrease design-cycle duration

- What is the proper way to integrate deployment/operations into the Design, Development, Test and Evaluation (DDT&E) phase?

How can data analytics and better data capture improve testing? Who has this data? Why can't it be collated and organized like other large data sets?

What data (e.g., EEE parts) from prior projects is available to inform new and developing projects?